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UK CL (Edition N) C1A APDT
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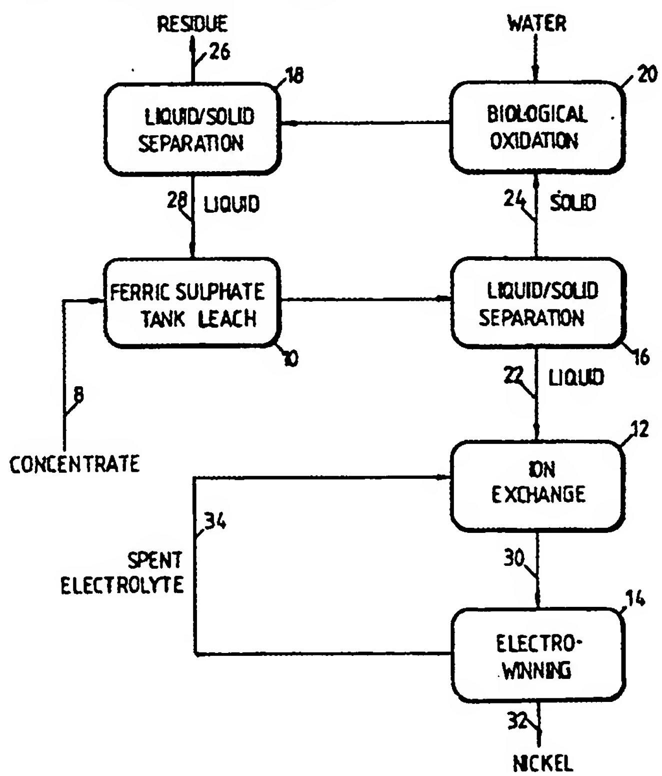
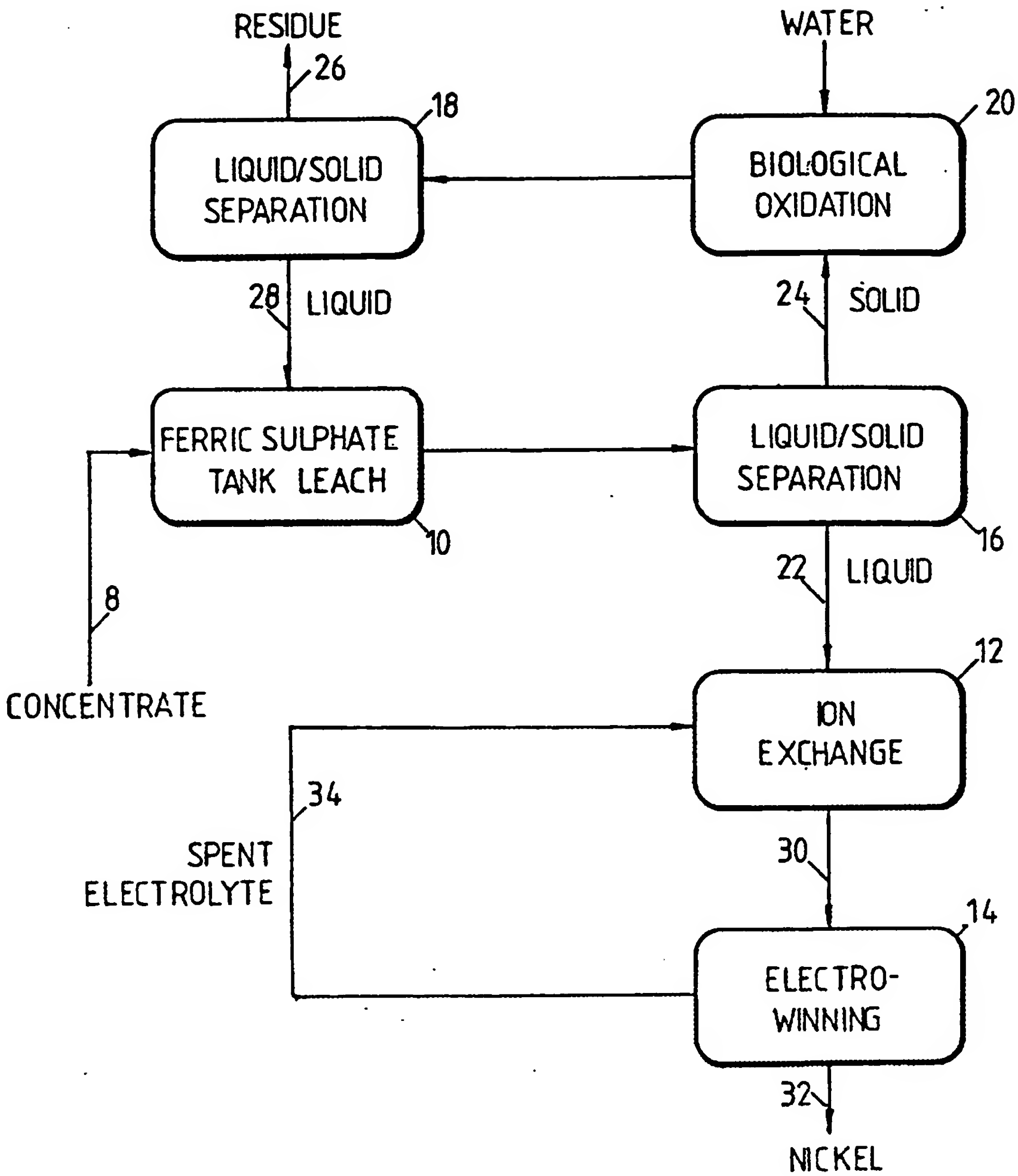
(54) **Recovering nickel from a nickel sulphide concentrate**

(57) A process for producing ferronickel wherein a solution of nickel sulphate and iron sulphate is produced by leaching a nickel sulphide concentrate. The solution is subjected to an ion exchange step whereafter ferronickel is electrowon from an eluate solution of nickel.



GB 2 291 870 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.


RESIDUE
26
18
LIQUID/SOLID SEPARATION
WATER
20
BIOLOGICAL OXIDATION
28
LIQUID
24
SOLID
FERRIC SULPHATE TANK LEACH
10
LIQUID/SOLID SEPARATION
16
8
CONCENTRATE
22
LIQUID
12
ION EXCHANGE
34
SPENT ELECTROLYTE
30
14
ELECTRO-WINNING
32
NICKEL

NICKEL RECOVERY

This invention relates to the recovery of nickel from sulphide ores.

Nickel metal has been recovered from nickel sulphide bearing ore bodies by conventional procedures wherein the ore is ground fine and the nickel sulphide minerals are concentrated by froth flotation to produce a nickel sulphide concentrate. The nickel sulphide minerals may be present as pentlandite, pyrrhotite, millerite or other sulphide minerals.

The concentrate is treated further by smelting and reduction to produce a nickel bearing matte which contains nickel, cobalt, copper and iron. Various techniques are known for refining the matte to produce pure metal. These include leaching, pressure leaching, hydrogen reduction, electrowinning, the Carbonyl process, and so on. In general the refining processes are expensive and produce nickel metal to varying degrees of purity, roughly dependent on the cost of the process employed.

Nickel metal has many applications but its use in stainless steel is becoming more dominant. For stainless steel, nickel metal does not need to be as pure as for other applications and it can be used as ferronickel. Ferronickel is produced from ores of nickel other than sulphide ores. If however it is possible to produce ferronickel from sulphide ores then,

when nickel for stainless steel is not required in a pure state, it is possible to avoid refining to produce pure nickel.

The invention is concerned with a process to produce impure nickel in the form of ferronickel when the starting material is a concentrate of nickel sulphide minerals.

The invention provides a method of producing nickel from a nickel sulphide concentrate wherein the concentrate, in slurry form, is leached in one or more tanks, a solution of nickel sulphate and iron sulphate, produced by the leaching, is treated with a solvent extraction or ion exchange reagent which is selective for nickel over ferrous iron whereby the nickel is separated from the iron and transferred in a concentrated form into an eluate solution, and the eluate solution is subjected to an electrowinning process to produce ferronickel.

The leaching process may include the following:

treating the concentrate with a solution of ferric sulphate, separating the product thereof into solid and liquid components, directing the liquid component to treatment with the said solvent extraction or ion exchange reagent, subjecting the solid component to a biological oxidation process, separating the product thereof into solid and liquid components, and

contacting the liquid component with fresh concentrate.

The biological oxidation process may be carried out using Thiobacillus ferrooxidans.

Preferably a mixture of Thiobacillus ferrooxidans, Thiobacillus thiooxidans and Leptospirillum ferrooxidans is used in the oxidation step.

The Thiobacillus ferrooxidans preferably mainly consists of the strain TF-FC-1 as described in the specification of Australian patent No. 618177. This strain forms the subject of a deposit under Accession No. N 90/010723 at the Australian Government Analytical Laboratories.

The invention is further described by way of example with reference to the accompanying drawing which illustrates in block form a flow diagram of the process of the invention.

The accompanying drawing illustrates the process of the invention applied to the production of ferronickel from a starting material which is a concentrate of nickel sulphide minerals.

The process includes the following main process steps: a leaching phase 10, which is carried out in one or more tanks, an ion exchange step 12, an

electrowinning stage 14, liquid/solid separation stages 16 and 18 respectively, and a biological oxidation process 20.

Nickel concentrate 8 is produced by finely grinding a suitable sulphide ore and then concentrating the nickel sulphide minerals by froth flotation. The nickel concentrate contains a high proportion of the mineral pyrrhotite. It has been found that pyrrhotite reacts very quickly with ferric sulphate, in the leaching step 10. The leaching step is carried out for any suitable period of time, but typically for from 12 to 24 hours. Iron is reduced to ferrous sulphate and pyrrhotite is dissolved, according to the reaction:

$$Fe_7S_8 + 7Fe_2(SO_4)_3 - 21\ FeSO_4 + 8S$$

The product of the leaching step is separated, at the stage 16, into a liquid component 22 and a solid component 24.

The solid component is subjected to bacterial oxidation 20 using one or more of Thiobacillus ferrooxidans, Thiobacillus thiooxidans and Leptospirillum ferroxidans. The Thiobacillus ferrooxidans is mainly constituted by the strain TF-FC-1 as defined in the specification of Australian patent No. 618 177, and forming the subject of a deposit made at the Australian Government Analytical Laboratories under Accession No. N 90/010723.

These bacteria are similar to those used in processes applied to refractory gold ores where iron, nickel and sulphur dissolve to form nickel sulphate and iron sulphate in solution.

The product of the biological oxidation is separated, at 18, into a residue solid component 26 and a liquid component 28.

The liquid component 28 has a large excess of ferric sulphate in solution. The solution is contacted with fresh concentrate 8.

The liquid component 22 produced in the separation stage 16 is directed to the ion exchange step 12. Nickel is absorbed from solution by an ion exchange resin which is selective for nickel. There are several ion exchange resins which can be used for this process which are marketed under the general grouping of chelating resins. These resins are selective for nickel relative to ferrous iron but not ferric iron. In the bacterial oxidation process however, as has been described, much of the ferric sulphate in solution is reduced to ferrous sulphate. The problem associated with ferric sulphate is thus largely eliminated and the chelating resins are effective in separating the nickel from the iron in solution and allowing the nickel to be transferred in a concentrated form into an eluate solution 30.

The solution 30 is subjected to a known electrowinning process 14 to produce an alloy 32 of nickel and iron. The solution, marked 34, remaining after electrowinning still contains nickel and is reused to elute further nickel from the ion exchange resin. Sulphuric acid is generated by electrowinning and is thus used, although additional sulphuric acid may still be required, for resin elution. The additional acid is added, as required.

It is to be noted that it may be necessary to remove at least some of the remaining ferric sulphate from the liquid component 22 by precipitation of the iron with an alkali such as lime. It is however not necessary to remove all of the ferric iron from solution because the ion exchange electrowinning processes will produce ferronickel, which is acceptable. As the leaching step 10 is carried out in one or more tanks it is possible to control the leaching process precisely to produce an acceptable concentration of ferric sulphate.

The biological oxidation step 20 is carried out under conditions described in the specification of Australian patent No. 618 177 where the optimum conditions of pH and temperature are described.

The ion exchange step 12 may be carried out in any of the commercially available systems. It has been found to be advantageous to use a

countercurrent fluidised bed column fitted with multiple stages separated by plates because stage-wise adsorption provides a more efficient process for achieving separation of nickel and iron while removing at least 99% nickel from solution.

The elution process is also carried out countercurrently so that a highly concentrated eluate is obtained, while efficient elution of the resin is achieved.

CLAIMS

1. A method of producing nickel from a nickel sulphide concentrate wherein the concentrate, in slurry form, is leached in one or more tanks, a solution of nickel sulphate and iron sulphate, produced by the leaching, is treated with a solvent extraction or ion exchange reagent which is selective for nickel over ferrous iron whereby the nickel is separated from the iron and transferred in a concentrated form into an eluate solution, and the eluate solution is subjected to an electrowinning process to produce ferronickel.

2. A method according to claim 1 wherein the leaching is carried out by treating the concentrate with a solution of ferric sulphate, separating the product thereof into solid and liquid components, directing the liquid component to treatment with the said solvent extraction or ion exchange reagent, subjecting the solid component to a biological oxidation process, separating the product thereof into solid and liquid components, and contacting the liquid component with fresh concentrate.

3. A method according to claim 2 wherein the biological oxidation process is carried out using one or more of Thiobacillus ferrooxidans, Thiobacillus thiooxidans and Leptospirillum ferrooxidans.

4. A method according to claim 3 wherein the Thiobacillus ferrooxidans consists of the strain TF-FC-1.

5. A method according to any one of claims 1 to 4 wherein the leaching is carried out for a period of from 12 to 24 hours.

6. A method according to any of claims 1 to 5 wherein sulphuric acid, generated in the electrowinning process, is used in the elution step.

7. A method according to any one of claims 1 to 6 wherein the ion exchange step is carried out using a multiple stage countercurrent fluidised bed column.

8. A method according to any one of claims 1 to 7 wherein the elution step is carried out countercurrently.

9. A method of producing ferronickel from a nickel sulphide concentrate substantially as hereinbefore described with reference to the accompanying flow diagram.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9515003.3
Relevant Technical Fields (i) UK Cl (Ed.N) C1A (APDT) (ii) Int Cl (Ed.6) C22B	Search Examiner C A CLARKE
	Date of completion of Search 3 OCTOBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1 TO 9

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	US 5397380 (BOLIDEN)	

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).